The Builder.

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THE failure of the cast-iron girder-bridge at Chester, and its frightful consequences, cannot fail to cause much anxiety to every man engaged in construction, whether director or operative. Planned by one of the first engineers of the day, executed *without regard to cost*, the girders tested singly (at least so say the witnesses), the structure in use ever since *November last*, and yet on the instant, without a moment's warning, failure takes place, the whole is a ruin,—and property, and human life, and the happiness, perhaps welfare, of surviving relatives are sacrificed.

If security cannot be obtained with certainty under the circumstances attending the erection of this and similar constructions, how can it be looked for in those buildings where, cheapness being of necessity studied, the devisers and contractors are cramped and confined, and the *just enough* is all that is proposed: where the inquiry is, how little will do? and provision against extraordinary accidents cannot be considered.

A very rigorous inquiry into the cause of the failure which is now agitating the public is the first thing necessary. Is it to be looked for in the foundation, the masonry, or the iron? At present opinions vary considerably, but we have little doubt in our own minds that it will be found in the latter. Was the design of the girder a good one, and sufficient for the largeness of the span,—nearly 100 feet? How was the casting conducted? and, in short, where does the blame, if any, rest? Efforts will of course be made to shift it, but the public safety demands that it should be *correctly* arrived at. For some time past, as we happen to know, an impression has prevailed in the neighbourhood of the bridge that it was unsafe; the grounds for this impression will probably appear during the inquiry which is now going on, and in which many able men are engaged. In addition to those mentioned in our last, Captain Simmons, of the Engineers, and Mr. James Walker, have been sent down by the Railway Board, and Major Foster is watching the proceedings on the part of the Admiralty. General Pasley is also there, and Messrs. Locke, Vignolles, and other engineers.

Before making any further observations, we proceed to lay before our readers such portions of the evidence already given, as bear most strongly on the questions wherein we are more particularly interested.

The engine driver proved that the speed at which the train was travelling when it reached the bridge was about 15 to 20 miles an hour. He had been on the line about six months, and had never felt any particular vibration or subsidence when passing over this bridge.

Sir E. S. Walker, acting as foreman of the jury, said that reports had described the deflection of the bridge to be at times as much as from 3 to 6 inches. The jury wished that a pole should be fixed under one of the arches with a painted top, and a train passed over, so as to ascertain its precise state. This was promised.

Thomas Frith, who was fishing in the Dee, within a 100 yards of the bridge, when the accident occurred, saw a large piece of the iron girder fall from the middle buttress, and the train follow amidst a heap of stone and rubbish. He had been under the bridge on the same day, when a previous train was going over, and then saw *the same iron girder bend, which afterwards broke.*

Mr. Thomas Alfred Yarrow, who was selected by the coroner and jury to examine the bridge, said:—

I have been a civil engineer for the last 12 years. I have held the appointment of bridge-master for Chester for some time, and have no connection at present with any railway. I have made the construction of bridges my entire study. I have made an examination of the railway bridge over the Dee, and I now read my report of the inspection:—"Upon examining the bridge, I found that the masonry and ironwork, with the exception of that part of each which has fallen, were in an apparently sound state. The principle of the bridge is that of trussed girders of cast metal resting upon stone piers and abutments, which are parallel to the course of the river, but askew to the railway above. Each girder consists of three pieces, having vertical flanges, with bolts at the joints, and, in addition to being bolted to the full depth of the girder, each joint is surmounted by a segmental piece, to receive which, notches have been cast in the upper surface of the girders. The tension rods descend in an oblique direction to each joint, and are carried horizontally between them; they consist of separate bars of wrought iron, which are secured to each other laterally by clips. The portion of the bridge which has fallen consists of one outside girder on the Salteney side of the river, with the attached platform and transverse tension rods. Two stones, composing part of the string course, and acting as a bed for the girder on the Salteney abutment have fallen, and also the corner stone at the acute angle of the opposite river pier upon which the broken girder rested. The girder itself is broken, having two fractures in the length near to the Salteney abutment, and one in its centre. Having premised this short description of the construction of the bridge, and its present appearance, I may proceed to detail the facts which I have remarked during my investigation, and which have enabled me to arrive at a confident conclusion as to the cause of the accident. My attention was in the first instance directed to an examination of the fractured ends of the girder, for the purpose of ascertaining whether any defect had existed in the castings. The appearance of the broken surface led me to conclude that the castings had been sound, and the tension bars, as far as they have yet been recovered from the water, are unbroken. From calculations which I have made of the strength of the girders, taken from an actual measurement of the section at the point of fracture, I find that, independent of any additional strength that may be obtained from the tension bars, the girders alone are capable of sustaining a much greater weight than could under any ordinary circumstances be placed upon them. The breaking weight of each girder I calculate at 74 tons, supposing the weight to be concentrated over one point, and of both girders 148 tons. But it is an admitted principle that a beam will carry twice the weight, distributed over its whole surface, that it will bear upon one point. We can therefore conclude, that twice the above weight, $148 + 2 = 296$ tons, is the breaking weight of one bay or opening of the bridge for one line of rails. The weight of girders and platform is, at a rough calculation, about 90 tons, which must be deducted from the foregoing quantity; we have therefore 296, less 90, equal 206 tons as the breaking weight; and this is altogether without reference to the tension bars. From the above facts, I concluded that the accident did not arise from the breaking of the girder as a primary cause, and I therefore directed my attention to the state of the masonry and to a consideration of its sustaining power. Having carefully examined all the displaced stone and their respective beds, I found that one, previously named as forming the acute angle of the river pier, and upon which one end of the broken girder rested, was totally inadequate, in its form and bearing surface, to its important situation. This stone had sustained nearly three-quarters of that portion of the flange of the girder which rested upon the pier. The area of its lower surface is 24 feet 6 inches, of which 11 feet 6 inches only was bedded on the pier, leaving 13 feet to overhang as a cornice. The stone was not connected by cramps or ties with the adjoining masonry of the pier. The railway over the whole bridge is curved. The broken girder supporting the outer side, and being subject to a greater lateral force than the girders forming the inside radius of the curve, I consider that this lateral force, acting during the passage of each train, must have so far loosened the inefficient masonry as to cause a displacement of the girder itself and its consequent fracture."

When examined, he said:—If I had had the management of the bridge I certainly should have had a greater strength of masonry round the girder. Considerable vibration would be likely to disturb the masonry. I tried the deflection of the arch opposite the third one. An engine and loaded ballast waggons, in weight about 50 tons, passed over it, and the deflection was about one inch and a third.

Mr. Robert Board, superintendent of the Mausley Iron Works.—The girders of the Chester railway bridge over the Dee were manufactured at those works. They were tested before sent to the railway. Each girder was placed side by side and tested by 50 tons of iron being put on them in the centre. We took the deflection on every five tons, but have not got the particulars of those deflections. The ordinary pressure on the girders passing over them would not exceed 50 tons. After the girders had been tested we found a flaw in one of them: it was a mere honey-cake, and it was rectified before it was sent away. I have since examined the girder, and found that the accident had not resulted from the flaw. The fractures were in the sound metal. I superintended the fixing of the girders. There are many railway bridges of the same kind. On the Trent Valley line there are eight of the kind. It is not opened to the public as yet, but on the Blackwall Railway there are several that have had heavy trains passing over them for years. The one over the Dee is the largest. I never heard of any of them giving way. Have been several times to view the bridge when trains were passing over it, and found the deflection very trivial, not much more than an inch. Have heard that it was considerable.

Mr. Tyrrell said, that as there seemed to have been a feeling that the bridge was dangerous, and as the line was leased to the Chester and Shrewsbury Railway, probably the gentleman who represented that company would state whether they had received any communication to that effect.

The coroner remarked—Most certainly the notion had prevailed for some time that the bridge was unsafe. He did not know from whence it emanated, but it was a well-known fact that many had declined to cross it. He had laboured under that impression and had not risked himself on it.

Several who were present made a statement to the same effect. Major Robe, being examined, said he had watched the construction of the bridge, and had expressed apprehensions as to its security. [We should like to know the major's reasons]. He differed from Mr. Yarrow as to the cause of the accident, and attributed it rather to the breaking of the girder than the insecurity of the masonry.*

Mr. Lee, clerk of the works of the Chester and Holyhead Railway, said—I superintended the construction of the bridge. The abutments on the Salteney side are piled for a foundation. Upon the piles were placed a strong flooring of timber, and upon that platform we built the abutment with ashlar stone facings, 10 feet in thickness; the piles are built on hard clay, and all the materials are of the

* According to the newspapers the Rev. A. Lees, the principal of Chester Training College, says there are three causes for the accident:—1st, the defect in the masonry; 2nd, the peculiar vibration, brought about by mechanical circumstances, the bridge, although not a suspension bridge, was a structure that would vibrate in three ways—vertically, horizontally, and also with a slight and almost imperceptible longitudinal motion; 3rd, the horizontal vibrations from the centrifugal force of the train, passing over

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